NOAA –SEARCH
Metrological Services Canada
CANDAC
National Institute of Polar Research – Japan

Summary of Toronto Coordination Meeting and Eureka-Alert Site Survey

August 18th-22nd, 2003.

Toronto Meeting Participants – August 18th, 2003
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Background

NOAA (National Oceanic and Atmospheric Administration – U.S) has recently received funding to establishing a long-term Atmospheric Research Observatory in North-East Canada with an emphasis on clouds, radiation, aerosols and surface fluxes in the troposphere and planetary boundary layer. A group of Canadian scientists (PI Jim Drummond) associated with the University system have a proposal in process (CANDAC-Canadian Network for Detection of Atmospheric Change) which has many overlapping objectives and plans with the NOAA-SEARCH Atmospheric Observatory program. Their main objective would be to reopen the ASTROlab, and in addition to SEARCH objectives, they also have interests in the middle and high atmosphere. The National Institute of Polar Research (Japan) have a history of radar, aerosol, and sea ice thickness measurements in Scandinavia, and would like to now expand these operations to the Canadian and Russian Arctic. Meteorological Services Canada has a long history of routine weather and research operations in Alert and Eureka. The purpose of the Toronto meeting was to lay the groundwork for a multi-National program that would serve mutual interests, leverage resources, and avoid redundancies.

Alert and Eureka are located in the extreme northern part of the new territory of Nunavut on Ellesmere Island. Access to Alert and Eureka is either through charter aircraft from Resolute or Iqaluit (formerly Frobisher Bay). Iqaluit is the new capital of Nunavut, and is a rapidly growing community of 6000 people which serve an additional 9000 people in the outlying communities on Baffin and Ellesmere Island. Iqaluit has many services including hotels, restaurants, colleges, well stocked general stores, and a radio shack. Transportation to Alert is also available through military transport from Trenton or the U.S. airbase at Thule, Greenland.

ALERT (82.5 N, 62.3 W) Contact: Andrew Platt

Facilities

Alert is the location of a MSC weather station and a **Global Atmosphere Watch (GAW)** laboratory, with the main site infrastructure being provided by a Canadian Forces Military Base. The military base was established in 1956, and the GAW Laboratory was built in 1983. The GAW station was expanded in 1992 and currently makes extensive atmospheric chemistry/constituents measurements. In the 70-80's the military maintained 300 people on site, but now there are about 70-80 and it is expected that there may be even less in the near future. Alert is a listening station, and the only request we received while on the base was that we not take photographs of the antennas on their operations building. There is no ship service to Alert due to the shallow bay, and supplies are provided annually by the "Box-Top" operation when a round-the-clock transfer of goods between Thule and Alert is accomplished with Hercules aircraft.

The GAW Observatory is 7 km inland from the Base at an elevation of 600 ft ASL. The road is not plowed, but track vehicles are available allowing year-round access. Near the GAW site, there is a moderately sized trailer, the **Special Studies Trailer (SST)** that is 500-700 m from the GAW that is available for short-term science studies. The SST has power, but no communications. The GAW Observatory is a permanent building with

power, heat, and is on an internet. The GAW operations are monitored remotely from the MSC weather station at the Alert base facilities, and at present, the MSC staff only visit the site twice a week unless operations appear to be abnormal. The GAW observatory has an externally accessible, walkup tower with large metal grid platforms. The platforms are already congested with various apparatus, rail-mounted instruments, and two intake stacks for high volume air studies. The two intake stacks are 8" plastic and 4-5" metallic, and rise about 3 m above the platforms. If SEARCH were to deploy at this location, a new platform would have to be constructed for the radiometric suite and the all-sky camera. The GAW Observatory is not designed to be residential, however, there is a 3 person emergency shelter on site.

The interior of the GAW laboratory appears to be fully utilized, and but could accommodate a limited amount of additional equipment to support BSRN activities and SEARCH aerosol measurements. It is storage for a number of compressed gases which may make it unsuitable for some SEARCH equipment from a safety standpoint. By design there is very little air contamination at the GAW observatory from the Alert base since present and historic measurements are aerosol and chemistry related. Because it is a "clean air" site, no vehicles are allowed in the immediate facility and the last ½ mile must be traversed by foot (safety lines are in place). Traveling on foot will be an issue in some weather conditions, but bears are infrequent in Alert.

There is an existing 20-meter meteorological tower near the GAW station has not been maintained due to the fact that MSC safety policies restrict employees from climbing towers. The tower still has power, and has sliding booms at 2 levels. Mention was also made of some 10 meter tipping towers, and there are unused communication towers on site that are 120 meters high. **(Note: If NOAA would like to use the existing towers, it may be necessary to head off decommissioning efforts that could occur in the near future)**.

The most promising building for SEARCH lidar and radar operations at the Alert site is the **TX building** and was previously a military transmission site**.** The TX building is located about ½ mile downwind from the GAW laboratory and has been given to MSC Canada; MSC presently has no use for the building and has indicated that it may be available. The TX building is very large, one-storey, rectangular building (about 4000 square feet) that is divided at one end into a sleeping area, kitchen, common area and storage, but is otherwise open. The ceiling is warehouse height, approximately 25 feet, and the roof has a slight pitch and is made of corrugated steel. The building is presently heated and appears to have power and communications services already in place that would far exceed the needs of any SEARCH related instruments, including the cloud radar. If sensors were to be mounted on the roof, modification would be necessary for access both from the inside and outside. There is a 150 kW generator that is new and operates as backup in the event that power from the main base is interrupted The area around the GAW/SST/TX installation also appears to have many existing tower anchor points and platforms remaining from communications towers that have been removed.

Transportation to Alert is by charter or military aircraft, and the runway can accommodate 727 jet aircraft. First Air may begin providing commercial charter service to Alert. The military flights operate erratically with frequent cancellations between Trenton and Alert; these are direct and inexpensive, but available only on a space available arrangement. Getting "stuck" in Alert on the time scale of a few days to weeks seems to be inevitable when using this mode of transportation. Note: It is likely that Spring/Summer flights are considerably more congested and less dependable than the winter flights.

Personnel at Alert are housed in one very large building that has dormitory wings (each with it's own bar), a communal bar, a recreational radio station, a woodworking shop, a music studio, a cafeteria, a library, a barbershop, a store, and workout facilities. The station has sufficient bandwidth through a microwave link to support 2 regular television stations. There is no doctor on site; medics are available and serious medical situations require evacuation to Thule. The base reportedly has a large garage, machine shop and wood shop although time did not allow us to tour these facilities. MSC has some very nice and spacious office space immediately adjacent to the military weather office at the main base.

Environment and Existing Measurements

Alert is the most northern year-round inhabited location on the planet. It faces the Lincoln Sea, and Greenland is easily visible across a narrow channel to the southeast. Alert is normally ice-bound year round; during the site visit the ice appeared to be broken, and there were areas of open water, but ice was packed up tight against the shore (although not anything I would have cared to walk on). Sunrise is on day 60. There is a predominant southwesterly, katabatic flow from the higher terrain (23 west relative to grid-south). The GAW/SST/TX site is relatively flat on a broad undulating plain, and may be sufficiently inland to avoid coastal effects for smaller footprint satellite comparisons. Alert Inlet and Campbell Lake have been monitored for ice thickness since the 1960s. There is a greenhouse gas focus, with 2x daily weather balloons and 1x week ozone sondes, UV measurements using Brewer instruments, flask sampling (in collaboration with CMDL), continuous surface O_3 measurements, CO_2 measurements, and precipitation with NIPER gauges. Standard surface meteorology measurements are made at both the GAW site and the base. These are not completely redundant, and there are noticeable differences. Upper air measurements are made at the base by the military. Surface ozone measurements have been made since 1992. There are also mercury and bromine records; bromine is a source indicator. There have also been intensive photochemistry measurements. Snow chemistry and in-snow processes appear to be quite complex and important. Expansion of chemical and physical aerosol studies is planned for the GAW observatory, including redeployment of a 3-channel nephelometer. Frost flowers and the chemistry involved are an active area of research. Whereas the physics of frost flowers are understood, the chemistry of these features is an area of current research. Alert experiences many episodic black carbon and CO_2 events due to long-range transports of polluted of winter air over the pole. Alert is reported to be foggy in the summer, and mostly clear in the winter, spring, and fall. There are 3-4 permafrost monitoring sites between the base and the GAW/TX/SST site with bore holes as deep as

40 m. The Special Studies Trailer is presently housing a year-long (April 2003-May 2004) sensible heat and momentum flux experiment being conducted by Ralf Staebler. He is utilizing a French REMTEC sodar (52 speakers), and a 3 sensor mast (about 3 meters) with two small, fine scale Japanese sonics on the bottom and top levels, and a 2nd larger sonic at the center level. Seismic measurements have been made by Natural Resources Canada since the 1970s. The Lunar Launch Program has used Alert as a site to test extra-terrestrial vehicles suggestive of what the surrounding terrain is like. Alert is the location of the Polar Sunrise experiment (ozone and chemistry studies).

Eureka (80.05N, 86.4243 W) Contact: Brian Howe

Facilities

Eureka is a MSC weather station, the location of the ASTROlab facility and has a Canadian military presence (Staff = 8 to 40 depending on time of year) for maintaining communications. Operations in Eureka commenced in 1947. It is the site of a satellite uplink station. Eureka is at the farthest north latitude where there is still a line of sight to the geosynchronous satellites and there is regular TV reception. Eureka and Alert are connected with land-based microwave transmitters. The ASTROlab was built in 1993 but is presently closed due to lack of operating funds. It was designed to be a year-round facility, but apparently most of the operations occurred in the winter and spring. Supplies are provided one every other year by icebreaker, and every 3 weeks by charter aircraft from Resolute. The station has two 230 kW generators and one 135 kW generator. Heating at the station is achieved with a heat recovery system, and new ecologically friendly septic procedures are being instituted. Eureka uses 1.2M liters of fuel/year. There is a new garage facility oriented towards vehicle maintenance, and an older, vacated **garage** is available for use. It is a heated space of about 2800 square feet with power. There are number of unused towers and tower parts around the station, and underground cabling provides power to a number of radiometric site that are several hundred feet distant from station buildings.

The **ASTRO (Arctic Stratospheric Ozone Observatory) Laboratory** at 2500 ft elevation is 14 km from the weather station, and normally accessible year round by wheeled vehicles. A track vehicle is available if necessary. (Note that the weather station is at sea level). The station manager is Hans Fast in Downsville. The road maintenance is the responsibility of the weather station, the military and the Laboratory depending on the section involved. One expense of opening the laboratory would be road maintenance for the final section (2 km) leading to the laboratory. The **ASTROlab** has power, is a heated solid structure, with nicely designed laboratory and office space. The ASTROlab was designed for radiometric and stratospheric measurements. The roof top access and platforms, power, and lidar/radiometer viewing hatches (remotely operated) are excellent. The viewing hatches may require some modification if they are to be left open continuously. The roof has an elevated grated floor with an allowance for 3 feet of snow accumulation, and there are 11 15-amp outlets on the roof (each on a separate circuit). There is a table saw and a drill press in the laboratory and onsite capabilities for producing liquid nitrogen. The ASTROlab is on an internet that is artificially restricted in bandwidth by the military. The ASTROlab has bunking for 2-3 people, and a small

kitchen, however, it was not really intended as a housing unit, there is also a separate emergency shelter on site designed for 8 people. The ASTROlab is presently heated (cost=$7000 CND/year), and being used for storage for 2 lidars (ozone and aerosol) and a FTIR that belong to MSC and Japan

Transportation to Eureka is by charter aircraft from Resolute. At present there is a regular air charter every 3 weeks, it possible that passengers can get space available seats for a nominal cost. However, it is significantly more expensive to fly commercially to Resolute as opposed to Trenton, or even Iqaluit.

At the main station personnel are housed in a comfortable building with 2 common areas, and a dining room and that can serve about 16-20 people. The Canadian Forces has a separate housing facility near the airport. The station accommodates passing Arctic adventurers that run afoul of the weather for a public rate and there is a separate, more economical research rate that is offered to scientists. The local area abounds with wildlife including Arctic hare, wolves, Arctic fox, muskoxen and a variety of birds. Polar bears are an issue, and travel outside requires checking out, and carrying a radio and pepper spray (one would hope that the approaching bear will be downwind). There is one tower on site that is bent from being rammed by muskoxen during mating season. There is a small recreational greenhouse on site that is intermittently maintained based on interest, and a workout area. There is no doctor on site, and medical emergencies would require evacuation to either Resolute or farther south. The materials for a new, modernized housing facility are on site, and it is expected that the construction will be completed sometime in the next 20 months.

Environment and Historical Observations

Eureka is located on the west of Ellesmere Island on a small inlet that connects to the much larger Eureka Sound. Given the immediate proximity of Axel Heiberg Island to the west (Ellesmere and Axel Heiberg Island fit together like puzzle pieces), Eureka is essentially near the center of a patchwork of environments including low lying tundra, inland-waterways and mountains. There is an FTIR (MSC), an ozone lidar (MSC) and an aerosol lidar (Japan) installed in the ASTROlab, none of which are currently being operated. The weather station has long term records with triple redundant GPS, LORAN and VLF sounding systems, launches are twice daily. Ozone sondes are launched 1x/week and there are surface Brewer measurements and some radiometric measurements. There are annual wolf surveys, and there is a tidal gauge in the sound, and a history of off shore ice thickness measurements. The Communications Research Laboratory of Japan has some geomagnetometers on site, but it was not clear if they were operating. Over the two days we were on site, the sound went from completely ice free to packed with loose ice as the weather and wind direction changed.

Station Comparisons

COMMUNICATIONS: Eureka is the most northernmost latitude at which the geosynchronous satellites are visible, and consequently has a large satellite uplink station that is connected to Alert by overland microwave links. Thus, the bandwidth from the two sites is identical. Eureka has regular TV stations, and the bandwidth available to MSC at Eureka and Alert is artificially bandwidth limited by the military to 56K/sec. Cost of bandwidth was quoted at $1000 dollars CND/Kbyte/sec/year.

CLOUDS: Alert and Eureka appear to have similar upper air wind trajectories and transport paths. Both appear to have similar cloud climatologies (20-40% overcast) with more clear skies in winter and spring. However, these may be inexact and Bruce McArthur commented that there were no surface cloud-type observations for the last 7 years at Alert, only fractions. There is anecdotal information that Eureka has more clear skies, however, Bruce's analysis showed that Eureka is somewhat cloudier than Alert. It is not apparent if clear means sunny/starry with broken clouds and optically thin clouds or if it indicates a true absence of clouds. At both sites there are ceilometers, but the data has not been archived. During the August 18-24th site visit, both Eureka and Alert appeared to have significant cloudiness as did the entire NE Canadian Arctic region, including Iqaluit, Hall Beach, Resolute, Eureka, Alert, Pond Inlet, however, it appears we were traveling in one of the cloudiest months of the year.

FACILITIES: The ASTROlab would be a turnkey facility that would require virtually no modification to be suitable as an observatory site, especially for aerosol, radiometric and lidar measurements. If it not utilized in some manner in the near future, Canadian Environmental laws require that it be dismantled at an estimated cost of $1.5M CND which would be a terrible loss to Arctic science. The GAW/TX/SST site at Alert is also a very usable facility, and for many applications better situated because of the more uniform surrounding terrain. However there are likely to be more infrastructure development costs involved with modifications to the GAW or the TX buildings.

PERSONNEL: MSC personnel at Alert and Eureka may be available on a contract basis to NOAA/SEARCH to aid in operations. If CANDAC commences operations in Eureka, there will be additional opportunities for sharing personnel costs.

BSRN and FLUXES: Deploying radiometers to meet BSRN standards near the MSC Eureka station building is problematic due to the sloping terrain away from the fiord and the number/density of buildings in that vicinity. Turf is perturbed due to a number of roads; traffic is not insignificant and can raise dust. A potential site was identified at the northeast end of the runway but this is not co-located with existing surface meteorology instrumentation and poses additional logistical concerns and expense to set up and operate there as power and communication runs would need to be extended. In the future, the Eureka airport site may be increasingly affected by air traffic, exhaust plumes/dust, as the site becomes more popular for ecotourism and scientific exploits. In contrast, the ALERT GAW/TX/SST site would easily meet specifications of a BSRN site by placing an albedo rack at least 180 m away from any building and upwind to the south where

drifting should be minimal. The region around the GAW laboratory is extensive, flat, would provide representative flux and radiation/albedo measurements over a large area.

HISTORICAL MEASUREMENTS: The Alert and Eureka sites both have a long history of standard meteorological and upper air measurements and ice thickness measurements. The Alert site has the added advantage of the long-term greenhouse gases/chemistry measurements. The availability and quality of these data sets needs to be carefully assessed. The desirability of collocating cloud and aerosol measurements in conjunction with long-term gas and chemistry measurements makes the Alert site attractive. In Alert, much of the standard meteorological observation and upper air work is done by the military. It would be useful to ascertain if the Eureka and Alert meteorological data sets are comparable with respect to quality control and methodologies.

TRANSPORTATION to the two sites is comparable, and the MSC managers for Alert and Eureka were discussing the possibility putting together a regular Eureka-Alert charter since the military transports were becoming so unreliable. If CANDAC and SEARCH proceeded, this would become increasingly feasible as the organizations cost-shared.

Science Issues

The mix of clear and cloudy conditions at either Alert or Eureka will allow aerosol-cloud studies that are one of the main focuses of the project (linking changes in cloud properties to anthropogenic forcing). Clear conditions will allow the aerosol sensors (e.g. lidar, sun and star photometers) to make measurements through the depth of the atmosphere to augment surface aerosol sensors (e.g. particle counters) and characterize the aerosol properties of air masses. The microphysics of proceeding and following cloud events (determined with radar and radiometers) can be studied for aerosol related effects.

The Eureka ASTROlab at 2000 ASL ft will often be above cloud base, and some low-level cloud processes may be missed if the cloud radar and lidar were located at the laboratory. At the same time, the ASTROlab may provide opportunities for in-situ cloud and aerosol sampling and interaction experiments. The lidar and radar could potentially be located at the Eureka meteorological station.

Eureka and Alert represent very different Arctic environments as Alert is a coastal site (which may make it easier to compare to Barrow) and Eureka is centered in the middle of the archipelago. Eureka is somewhat closer to the region of AO related cooling that some studies have shown. Alert is more likely to have influences from Greenland. Any detected trends in Eureka will be easier to relate to ecosystem changes, but measurements in Alert will be more directly applicable to off shore ocean and icepack studies. These and other differences do not necessarily constitute “advantages” or “disadvantages”, however, these factors must be carefully considered.

The ASTROlab is located on a sharp ridgeline that drops off steeply on either side. It is the one of several parallel ridgelines and can be expected to have complex local terrain flows. Unless this kind of flow is of particular interest, it would not be an ideal site for flux measurements. Likewise, any radiation and albedo measurements will not be

representative over a wide area. Flux and radiation measurements in Eureka would be more optimally deployed near the Eureka airport where a fairly large level region of tundra exists. The area is flanked by a ridge on one side, and the fiord on the other.

Flux measurements are presently being conducted at Alert by Dr. Ralf Staebler . If possible results from his measurements should be examined to see what kinds of results he obtains to guide deployment of permanent flux sensors.

Kaz Higuchi at MSC indicated that he though that CO_2 flux measurements at Alert would be a waste of time. Alert is indeed an extremely barren environment compared to Eureka that has comparatively continuous and lush tundra vegetation including extensive regions or Arctic willow. However, the Alert site has sufficient to support Arctic hares and occasional caribou. In the immediate proximity of Alert, there are reportedly valleys where accumulated moisture supports significant vegetation.

Eureka is a somewhat better site with respect to CLOUDSAT overpasses, and would be more desirable for a Canadian Aircraft program that is planned for FY06 that will have heavily instrumented cloud aircraft.

Collaborations with NIPR and CANDAC

NIPR

NIPR scientists have collaborated since the early 1990s with Norway using research vessels in the vicinity of Ny Alesund (79 North). They have used vertically pointing radars and aerosol systems to study atmospheric constituents. Now, the group is interested in the Canadian and Siberian Arctic with intentions of making annual but short duration, intensive observations to study sea ice thickness offshore Alert. They will use moorings and/or buoys anchored to the ocean floor or suspended from multiyear ice to measure temperature, pressure and salinity profiles. The focus will be on the seasonal melt period in spring and summer when snow characteristics will also be monitored. Results will be used for satellite validations. Aerial surveys are also planned.

CANDAC

CANDAC aims to establish an atmospheric monitoring program including the troposphere, the middle atmosphere and the upper atmosphere. A number of the sensors proposed by CANDAC overlap with NOAA/SEARCH (e.g. a cloud radar) so coordination could be extremely advantageous. CANDAC will have a strong training component focusing on "the craft of taking measurements. Eureka is the chosen site of CANDAC interests because of a long standing program of studying the ozone layer there, and a commitment to reopening the ASTROlab. However, Jim Drummond indicated that deploying some of the CANDAC instrumentation at Alert might be a possibility.

The status of the project follows:

1. approval of pre-proposal (Stage II) is expected this autumn
2. full proposal (Stage III) will be submitted this winter

3. by summer 2004 a decision is expected
4. start-up would follow immediately, during summer 2004

Initial proposal is intended as a 5-year renewable project (avoiding the monitoring aspect); mostly to establish the facility firmly and show the value of scientific results.

Preliminary Recommendation
At present, it appears that deploying instrumentation at both sites may be extremely advantageous to the SEARCH-CANDAC, MSC and NIPR programs. A number of unknowns (for example CANDAC funding, frequency allocations for the cloud radar, operating restrictions for the HSRL lidar) need to be resolved, and a more complete survey of the existing literature of Arctic climate trends in Alert and Eureka needs to be conducted. However, based on existing information, a FY04 deployment plan for the NOAA SEARCH program will include:

1. Install a BSRN suite of radiometers at Alert.
2. Install a TSI 3010-S CN counter at Alert.
3. Install the cloud radar at Alert in the TX building.
4. Begin planning for installation of a second BSRN site in Eureka.

Action Items

- **Arrange teleconference to outline a memorandum of between NOAA, MSC and the Canadian military Forces.**

- **Draft the memorandum**.

- **Apply for frequency allocations** (for cloud radar) and determine operating restrictions (for HSRL lidar) at Alert and Eureka.

- Provide a NOAA/SEARCH **letter of support to CANDAC.**

- **Bruce McArthur should travel to Boulder** to conference with CMDL scientist and engineers on Arctic-specific requirements for the BSRN site.

- Establish a **joint EC-SEARCH-CANDAC website** to report progress, provide links to climate data and pertinent contact information, pictures etc.

- **NOAA/ETL will contact and coordinate with Ralf Staebler** whose current flux measurements could significantly impact design of future NOAA/SEARCH flux measurements.

Acknowledgments: The NOAA/SEARCH team members would like to extend our thanks to our Canadian hosts who could not have been more cordial. Maris Lusis organized a productive meeting in North York despite rolling blackouts in Toronto. The MSC offices were closed, thus the MSC staff members that attended the meeting did so

on a day of administrative leave. Brian Howe and Andrew Platt greatly facilitated our tours of Eureka and Alert and are continuing to provide critical information. The staff at Alert and Eureka accommodated our unpredictable schedules, and spent large amounts of time touring us through facilities on short notice and at odd hours. Ken Borek Air Ltd. Captain Scott Bruce and First Officer Steve Westberg assured our safety when conditions were, at times, marginal.